

REPORT
ON
THE
SOUTH MACLEOD
IRRIGATION
DISTRICT

BY
D. W. HAYS

Dec. 27th, 1921



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Edmonton, December 30th, 1921.

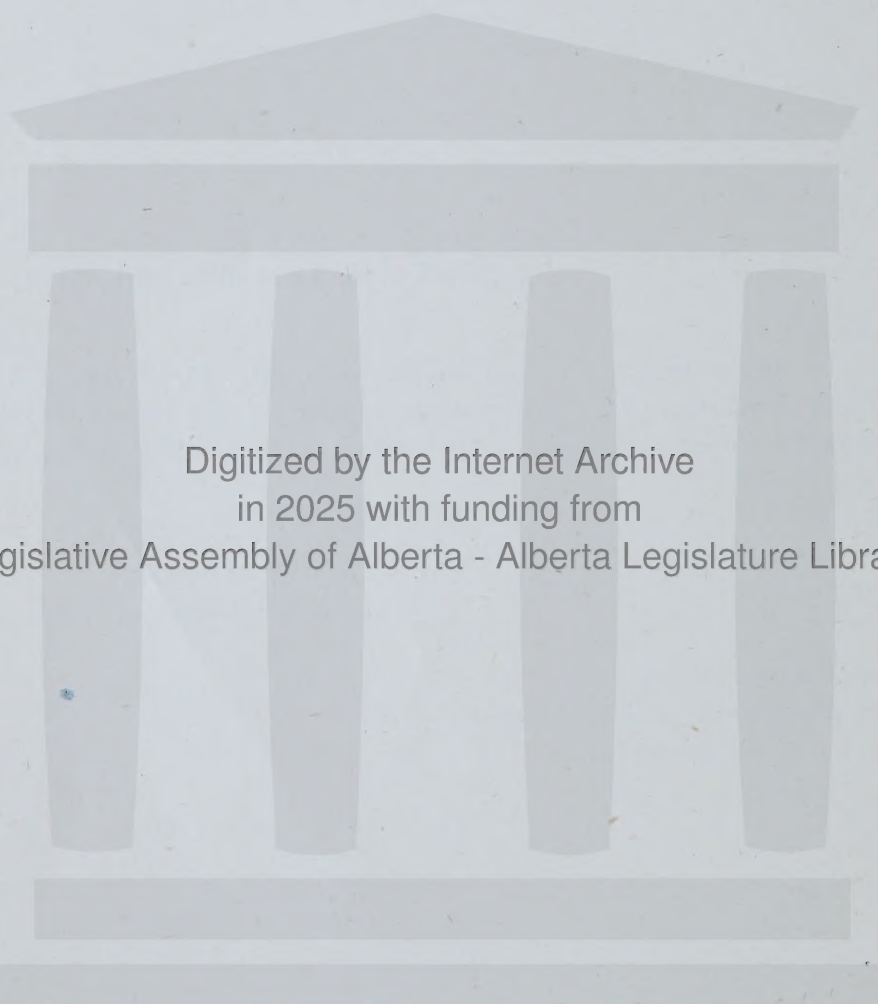
SIR:—

In accordance with your instructions, Mr. D. W. Hays, Consulting Engineer, was employed to report on the South Macleod Irrigation District project. His report is submitted herewith.

Your obedient servant,

L. C. CHARLESWORTH,
Chairman, Irrigation Council.

HON. ALEX. ROSS,
Minister of Public Works,
ALBERTA.



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Medicine Hat, Alberta,
December 28th, 1921.

L. C. CHARLESWORTH,
Chairman of the Irrigation Council,
Edmonton, Alberta.

DEAR SIR:—

I am submitting herewith a report on The South Macleod Irrigation District.

This has been compiled from information gained by an inspection of general conditions in the field and by a review of the maps, plans and data kindly furnished to me by the office of the Commissioner of Irrigation and the office of the Hydrographic Branch of the Department of the Interior.

You have advised me that the report might be serviceable to those in the District who are perhaps not familiar with many of the factors pertaining to irrigation development, but upon which an opinion is to be expressed in connection with further progress in the affairs of the District. I am, therefore, presenting a considerable amount of explanatory matter.

Respectfully yours,
D. W. HAYS.

SOUTH MACLEOD IRRIGATION DISTRICT

GENERAL DESCRIPTION

The South Macleod Irrigation District embraces an area of land lying west of the Belly and Waterton Rivers. The north-westerly part of the District joins the city limits of Macleod.

The District includes a gross area of approximately 96,000 acres, of which about 60,000 acres may be considered irrigable.

The irrigable land varies in elevation from 3500 near the south and to elevation about 3050 in its northern parts.

For convenience in dealing with the District as a whole, it has been divided into eight smaller districts, viz.: West Glenwood, Standoff, Wellsville, Belly River, Stowe, West Orton, East Orton and Monarch.

The surface conditions in these several sub-districts vary materially.

In the West Glenwood, Standoff and Wellsville Districts the surface is generally fairly smooth with slopes varying from 30 to 60 feet per mile. Excepting the steepness of the slope, for which numerous drops are required in the canal and ditch systems, the conditions in these three districts are generally favorable to the distribution of water by irrigation works.

In the Belly River, Stowe and Monarch Districts the surface is more irregular. Over part of these districts the surface is very steep and in other parts broken by ridges and coulees. These conditions, while requiring additional costs for irrigation works, especially with respect to drops and for detours of canal and ditch systems, do not adversely affect the irrigation of most of the land in a practical manner.

In all of the districts mentioned adequate drainage facilities are available.

The West Orton and East Orton Districts, which lie east and north-east of Macleod, do not present good surface conditions for irrigation. These two districts are irregular in surface and on the whole rather flat, consisting of numerous ridges and hills with intervening depressions. The ridges are disconnected and at such varying elevations that a ditch system can not be built continuously along the crests of the ridges. A considerable part of the West Orton District has a flat and irregular drainage toward the Oldman River. In the East Orton District there is no general drainage.

Much of the land in the low depression could not be drained even at the cost of extensive works. A considerable part of the area in these two districts is non-irrigable, either for the reason of being too high or too low although in other respects is suitable land for irrigation.

The steepness of the ground for a large part of the irrigable land in the District will require an unusually large number of drops, which will naturally add to the cost of works. The opposite condi-

tion in the northern part of the district, or broken character of the surface will require long detouring ditches run on a flat grade, with flumes, high embankments, etc., which add to the cost of distributing works.

The diversion works for the main canal have been considered at two sites, both of which offer expensive constructional features.

Near the upper end of the main canal a tunnel is required and for a short distance the main canal must be built along steep side hill slopes. The canal will cross several large coulees for which a syphon and flumes are to be provided. There is approximately 390 ft. of excess fall in the main canal requiring drops or chutes,

These various features make expensive construction works, but require in no case unusually difficult or hazardous undertakings.

SOILS

The soil in the Irrigation District ranges from clayey soils in the south end to sandy soils in the north. The north end of the district has been drifted badly by winds.

In various parts of the District gravelly ridges are found, some of which consist of heavy gravel and cobble stones, grading at other places into material containing smaller particles of gravel, sand, etc., and mixed with soil. At some places gravel shows at the surface and is of considerable depth and is found at other places covered with a depth of soil varying from a few inches in thickness to several feet.

Tests for alkali have been made over the District generally, but evidence of it in any quantity is confined to relatively small areas and in only a few cases of sufficient strength to warrant the land being excluded as non-irrigable. Where good drainage is to be obtained, as is the case in all but the West Orton and East Orton Districts, no bad results are expected from this source. Tests made to a depth of five feet at low points throughout the West Orton and East Orton Districts show no alkali. In the course of time, however, through the gradual process of concentration of alkali carried by water to low depressions which cannot be drained, and the gradual filling up of under ground water, it is likely that the low depressions in these two districts may become impregnated with alkali.

The clay soils in the southern part of the District are not so well suited to irrigation, more especially for alfalfa and root crops, as the sandy soils in the north of the district. Excepting, however, such areas of land containing heavy gravel at or near the surface, or land containing alkali of sufficient strength to warrant its exclusion, all of the soils in the district are suitable for agricultural development under irrigation.

LAND CLASSIFICATION

A classification of land with reference to its being suitable for irrigation has been made by the Dominion Government.

Each section has been mapped on a scale of 400 feet to 1 inch with contour intervals of 5 feet. A field inspection has been made and all areas considered to be non-irrigable are marked on the map.

The non-irrigable areas are excluded under the following conditions:—

(a) Land too high to be covered by ditches run on a practical grade or which can not be brought under irrigation by grading, or by the construction of flumes, levees, etc., at a concentrated cost for such work exceeding \$16.00 per acre.

(b) Swampy or wet land that can not be drained at a concentrated cost for drainage work exceeding \$16.00 per acre.

(c) Land in low depression which can not be drained and into which seepage from adjoining land may ultimately make swamp conditions or otherwise render it unfit for use. The area is estimated on the basis of receiving 10% of the water supplied to the area of irrigable land which would drain into the basin.

(d) Land too rough, rocky, rolling or of a pimply character, for which land preparation would be unreasonably high, above \$8.00 to \$12.00 per acre, or which has a slope in excess of 10%.

(e) Land containing alkali and which lies so that drainage and leaching would be impracticable.

IRRIGABLE LAND

The original estimate of the irrigable area within the district was 61,006.7 acres, but included 3,377.5 acres of Crown land. This area has since been excluded from the district provisionally, pending a decision as to the policy of dealing with Crown lands coming within the boundaries of an irrigation district.

A deduction has also been made because of alkali soils leaving the net area for which water right is now considered at 56,793 acres. Further adjustments of the irrigable area may be made as disclosed from time to time by detailed surveys and inspections, or with respect to the inclusion of crown lands in the district.

For the purposes of this report, in relation to questions of water supply, size and cost of work, etc., the area is taken at 60,000 acres.

CLIMATIC CONDITIONS

The amount of rainfall varies to some extent from the southern to the northern part of the district. There is a difference in elevation of approximately 400 feet. The difference in the yield of crop between the south end and north end of the district cannot be entirely attributed to soil, although the heavier soils in the south are better adapted to retaining moisture.

The climatic records at Macleod apply for the northern end. Some increase above the records for this station may be considered for the southern end for which no data are directly applicable, but may be estimated by reference to the data for Pincher Creek, which is about 20 miles west of the southern part of the district, and at an elevation of 3770. The district varies between 3500 and 3050.

RAINFALL

The following tables show the precipitation as obtained from records of the Meteorological Service, for the months during the growing season, April to September inclusive.

TABLE NO. 1.
RAINFALL AT MACLEOD, ALTA. ELEVATION, 3050

Year	April	May	June	July	August	Sept.	Totals April to Sept.
1895	-----	-----	-----	-----	0.94	0.08	-----
1896	0.40	2.74	0.48	1.27	1.99	2.23	9.11
1897	1.20	0.00	4.20	2.16	0.15	0.92	8.63
1898	0.27	1.59	1.90	1.57	4.04	0.85	10.22
1899	0.70	3.43	1.92	4.13	2.40	1.75	14.33
1900	0.60	0.81	0.28	2.67	0.64	2.39	7.39
1901	0.08	2.06	4.31	1.24	0.43	1.91	10.03
1902	0.20	2.65	2.90	1.20	0.22	0.51	7.68
1903	1.22	0.42	1.10	2.30	2.34	0.35	7.73
1904	0.10	0.15	0.65	0.65	1.36	0.90	3.81
1905	0.30	1.56	2.90	0.95	0.66	0.68	7.05
1906	0.51	6.56	3.54	1.68	3.26	0.14	15.69
1907	0.91	1.30	3.57	0.74	1.59	1.96	10.07
1908	0.34	4.71	6.83	0.77	0.59	0.89	14.13
1909	1.33	3.51	3.02	3.19	0.11	0.19	11.35
1910	0.16	0.99	0.78	1.99	1.04	1.34	6.30
1911	0.45	2.76	4.61	2.77	2.79	3.14	16.52
1912	0.67	0.60	1.65	3.32	2.01	2.01	10.26
1913	0.25	0.50	3.22	1.99	1.48	0.52	7.96
1914	0.31	3.00	5.83	0.15	2.49	0.38	12.16
1915	1.12	2.32	3.20	4.40	2.22	0.61	13.91
1916	0.51	2.60	2.59	4.65	5.03	4.42	19.80
1917	1.71	2.07	1.98	0.63	0.75	1.16	8.30
1918	0.30	0.97	1.27	1.19	1.57	1.31	6.61
1919	0.00	1.37	0.41	1.15	1.31	2.26	6.50
1920	2.89	1.69	0.66	3.48	0.15	0.00	8.87

TABLE NO. 2.
RAINFALL AT PINCHER CREEK, ALTA. ELEVATION, 3770

Year	April	May	June	July	August	Sept.	Totals April to Sept.
1895	0.42	0.49	4.36	4.68	0.61	1.84	12.40
1896	(No records)	-----	-----	-----	-----	-----	-----
1897	0.47	1.20	5.37	2.25	0.09	1.25	10.63
1898	(No records)	-----	-----	-----	-----	-----	-----
1899	(No records)	-----	-----	-----	-----	-----	-----
1900	(No records)	-----	-----	-----	-----	-----	-----
1901	-----	2.01	5.88	1.81	0.58	2.45	12.73
1902	0.85	8.22	3.69	5.40	1.48	1.87	21.51
1903	-----	1.88	0.68	4.65	4.47	1.67	12.35
1904	0.26	2.25	1.16	1.74	0.78	1.39	7.58
1905	1.76	1.97	4.49	2.87	0.11	0.34	11.54
1906	0.49	9.27	1.23	2.05	5.75	0.09	18.88
1907	(No records)	-----	-----	-----	-----	-----	-----
1908	-----	-----	-----	1.33	0.68	0.23	-----
1909	-----	1.19	2.00	6.86	0.25	0.86	11.16
1910	-----	2.55	0.65	0.20	1.86	3.87	9.13
1911	-----	0.91	4.05	2.70	6.66	-----	-----
1912	-----	-----	-----	-----	1.17	1.84	-----
1913	(No records)	-----	-----	-----	-----	-----	-----
1914	-----	-----	-----	0.61	4.51	1.37	-----
1915	1.80	3.37	7.68	4.01	1.24	2.31	20.41
1916	0.90	2.98	3.75	2.97	4.03	1.39	16.02
1917	2.02	3.37	2.25	0.24	1.77	2.14	11.79
1918	1.09	1.48	1.14	1.82	2.30	1.56	9.37
1919	0.33	2.12	0.54	0.99	0.75	1.89	6.62
1920	3.86	2.10	0.56	2.90	0.87	0.06	10.35

TEMPERATURE

The following table shows the average temperatures for the places given for the months April to October, during the years 1901-1912:—

Year	Cardston	Pincher Creek	Calgary	Gleichen	Edmonton	Macleod	Lethbridge	Medicine Hat
1901	-----	51.07	50.43	-----	51.75	53.39	-----	56.30
1902	-----	50.44	49.71	-----	51.71	53.60	54.59	55.97
1903	-----	50.37	49.34	-----	50.90	-----	53.80	56.24
1904	-----	57.05	51.09	51.69	52.35	52.50	56.69	58.10
1905	-----	50.70	49.97	50.30	51.99	53.37	55.13	56.77
1906	52.19	53.07	52.56	52.57	54.39	53.25	57.19	58.87
1907	51.07	-----	49.41	-----	49.60	51.43	53.74	55.35
1908	-----	50.23	52.00	50.74	48.10	53.13	55.24	58.17
1909	52.27	50.21	48.87	49.89	50.79	-----	54.17	57.20
1910	53.01	53.22	52.05	53.90	52.46	56.04	57.31	59.70
1911	49.25	-----	48.59	49.39	51.09	51.29	52.09	55.44
1912	-----	-----	50.27	50.37	52.59	53.04	-----	57.13
Aver.	51.56	51.82	50.36	51.12	51.48	53.10	55.00	57.10

The above records were obtained, already compiled as shown, and for the purpose of a general comparison the detail work necessary to compile data for later years is not considered necessary.

The district is situated at about the centre of a locality most frequently subjected to chinook winds, the warming effects of which materially moderate temperatures in the spring months. These winds, however, are very effective in drying out soil moistures, and aside from the question of soil drifting, have much to do with disastrous crop failures.

CLIMATIC CONDITIONS AS RELATED TO CROPS GROWN

The amount of rainfall and its distribution during the growing season is such, that grain crops have not been successfully grown throughout the district as a whole, excepting in the wet years.

In the southern part of the district very much better results have been obtained than in the northern part, due to both additional rainfall and a clayey type of soil. Probably in no year has there been an absolute failure in the southern part of the district.

In the northern part failures have been so frequent from lack of moisture and soil drifting, that practically all of the land lying to the east and north of Macleod in the West and East Orton and Monarch Districts are at the present time without any crops whatsoever, and completely covered with a rank growth of Russian thistle. In 1915 and 1916 (wet years) the yield of grain in these districts was very large, but due to drouth and winds since and the resulting crop failures, weeds and soil drifting, the entire area of these districts has become, by a gradual enforced abandonment of farming operations, a scene of complete destitution. Many farmsteads appear deserted, the owners being obliged to seek a living at other localities or occupations.

This section is in the most urgent need of irrigation, as, without it, and excepting for a cycle of wet years succeeding each other, the probability of which is not indicated by the precipitation records applicable to this locality, there is little possibility of undertaking any dry farming operations on these lands, to effect sufficient restoration to provide even a meagre livelihood.

For the district as a whole the agricultural results range from poverty-stricken conditions in the north to average results, good to poor, in the south. All of the district can be materially benefited by irrigation.

No definite information can be readily obtained for the district as a whole, as to yield of crops for different years. In wet years crops were good throughout, but in other years vary materially from fair crops to nothing, according to the year and location in the District.

At the southern end, yields may be considered to be similar to results obtained on lands immediately adjoining and coming under the United Irrigation District, for which the average results on the basis of wheat yields have been compiled as follows: for the dry years 1910, 1914, 1917, 1918, 1919, 1920, 1921 vary from 3 to 25 bushels; 1911 to 1913 inclusive an average of 35 bushels, and 1915 and 1916—50 bushels. In the northern part of the district equally good results were obtained for the wet years 1915 and 1916. For the seven dry years mentioned the average results are estimated to be from 0 to 10 bushels, and in 1911 to 1913 inclusive, 25 bushels.

These averages are indicative of general results at the two ends of the district with a gradual grading as to results for intermediate lands. Under the best dry farming methods, where practised, results higher than the averages given above have been obtained in the southern part of the district, but the best dry farming methods on the sandy lands in the northern part of the district have not sufficed during the dry years to produce crops of any material value. In fact, effort to conserve moisture by summer-fallowing under conditions of drouth, winds and lack of vegetable fibre in the soil, has resulted in much of the soil being blown away and piled at fences and other obstacles to depths of several feet.

The character of soil, length of and relative temperatures of the growing season are suitable to good agricultural results every year, if sufficient moisture were available.

Under irrigation the district should produce all crops successfully every year with the possible exception that frost may occasionally injure wheat, especially if not of a hardy variety. Wheat under irrigation matures at about the same time as it does in a wet year under dry farming methods.

From an irrigation standpoint, mixed farming is especially desirable. Greater benefits are obtained by growing forage crop such as alfalfa, mixed grass hay, oats, peas, barley and roots, corn and sunflowers for ensilage, all of which can be more profitably marketed through livestock. All of these crops respond better to irrigation than does wheat.

Wheat does not yield as well during hot years especially with hot winds, as it will during cool years regardless of the amount of irrigation applied. Under irrigation wheat will become soft, grading

No. 2 or No. 3. Wheat must be marketed through the elevators, requiring long hauls and as it is not stock feed, excludes profits to be obtained in feeding livestock.

Land will not produce grain crops continually because of depletion of the fertility of soil. Grain crops alone without rotation with other crops and without livestock will never yield the full productive value of the land.

The marketing of farm products through livestock, not only returns a greater value for the products raised, but affords the opportunity of conveying a large amount of farm products to the markets in condensed form, and retains fertilizer on the land necessary to future crops.

PROSPECTIVE CROP YIELDS UNDER IRRIGATION

At the present time there is abundant evidence of the success in growing crops under irrigation in various parts of Alberta.

Actual results are not obtainable for lands in the district, but the conditions of the district as related to crop production should not materially differ from the results which are being obtained about Lethbridge, records for which are shown in various publications.

The following information shows the average yields for the period of years shown for different crops under irrigation obtained at the Dominion Experimental Farms at Lethbridge and at Brooks, and by the Canada Land and Irrigation Company at Ronalane.

Location of Farm	Period of Years	Average yields for the period					
		Alfalfa Tons	Wheat Bus.	Oats Bus.	Barley Bus.	Peas Bus.	Potatoes Bus.
Lethbridge	1908 to 1918	4.0	53	108	78	41	487
Brooks	1919 & 1920	6.1	44.9	87.8	47.3	58.4	-----
Ronalane	1915 to 1920	3.1	43.0	86.1	55.4	37.9	332.2

These results were obtained under the best farming operations, but not necessarily under any better conditions than are to be had elsewhere in the southern part of the Province.

Considering various data on the subject and general knowledge of irrigation in Alberta, the following yields are estimated for the average conditions in the district on land well prepared, well farmed and properly irrigated.

Alfalfa	3.5 tons
Wheat	35 bushels
Oats	80 bushels
Barley	55 bushels
Peas	40 bushels
Potatoes	300 bushels
Mixed Grass Hay	1.5 tons
Corn and Sunflower, for ensilage	20 tons

WATER SUPPLY

The supply of water for the district is to be obtained from the Waterton River at a point in the N.W. Quarter of Section 18, T. 5, R. 27.

The amount of water at this place can be approximated by reference to records of the Department of the Interior for a gauging

station established near Waterton Mills and for a station near Standoff. The station at Waterton Mills is about 20 miles south of the proposed dam and Standoff 15 miles north. Between these two gauging stations a number of tributary streams enter the Waterton River. Those which enter above the proposed dam are Cottonwood Creek, Crooked Creek, Pine Creek, Drywood River and its large tributary, Yarrow Creek, together with drainage from several coulees.

Two smaller creeks enter below the proposed dam, viz.: Foothill Creek and Backfat Creek, together with drainage from small coulees.

Excepting for Crooked Creek no discharge records by months have been obtained.

TABLE No. 5

MEAN MONTHLY DISCHARGE OF WATERTON RIVER NEAR WATERTON PARK. DRAINAGE AREA 214 SQUARE MILES
RECORDS AVAILABLE JUNE 10TH, 1908 TO SEPT. 30TH, 1920

SEASONS	NON-IRRIGATING SEASON						IRRIGATION SEASON						Total acre feet
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.		Irrg. Season
1908	-----	-----	-----	-----	-----	-----	-----	-----	3811z	1853	485	235	(a) 316,479z
1908-09	427z	-----	-----	-----	-----	-----	242z	1527	4708	2141	783	315	568,440
1909-10	222	425z	-----	-----	-----	-----	1106	2145	1819	830	347	591	343,920
1910-11	1061	731	-----	-----	-----	-----	1035z	1650	3106	1136	744	1255	448,260z
1911-12	457	132z	-----	245	217	112	364	1509	1744	1205	454	270	609,882z
1912-13	330	371	181	121	110	110	373	1577	3383	1133	638	273	310,920
1913-14	384	267	179	161	134	131	611	1913	1993	905	431	394	420,240
1914-15	856	536	201	111	91	92	548	1369	1713	981	496	507	338,160
1915-16	539	384	197	123	174	276	449	1271	3423	2374	686	535	303,960
1916-17	192	157	98	123	89	78	115	1777	3001	1752	340	184	497,340
1917-18	141	118	149	390	162	136	500	1167	2396	634	339	258	423,240
1918-19	240	190	105	132	134	109	357	1705	1750	541	210	124	287,640
1919-20	103	99	116	116	128	97	161	1248	2569	1694	388	69	259,800
1920-21	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	69	370,080
Average c.f.s.—S	411	317	153	169	138	127	458	1572	2634	1321	488	401	-----
Average acre feet	25271	18863	9408	10391	7760	7809	27253	96659	156734	81226	30006	23861	495,241

Location of Station—In N.E. $\frac{1}{4}$ Sec. 8, T 2, R. 29, W. 4th, at traffic bridge below Waterton Lakes and about one half mile above the mouth of Crooked Creek.

Maximum and Minimum Stages—The maximum stage recorded is 7,750 c.f.s., June 10th, 1908, and minimum stage recorded 42 c.f.s., Dec. 1st, 1916.

Flood—On June 6th, 1908, the estimated discharge was 21,500 c.f.s.

(z)—partial record, not included in average.

(a)—acre feet during the irrigation season computed at 60 A.F. per sec. ft. per month.

TABLE NO. 6
MEAN MONTHLY DISCHARGE OF WATERTON RIVER NEAR STANDOFF, ALTA.—DRAINAGE AREA 740 SQUARE MILES
RECORDS AVAILABLE NOV. 5TH, 1915, TO SEPT. 30TH, 1920

SEASONS	NON-IRRIGATING SEASON							IRRIGATION SEASON				Acre Feet Irrigation Season	Total Acre Feet	
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July*	Aug.			Sept.
1915-16	.....	498p	303	199	673	673	785	1708	4819	2939	781	647	(a) 653,640	846,306
1916-17	309	347	220	160	121	119	403	2432	3868	1950	449	228	535,620	641,806
1917-18	173	.....	.....	.....	.....	.....	.....	1504z	2559	730	415	421	337,740	315,028z
1918-19	314	206	118	89	151	112	402	1978	1794	751	306	164	299,580	386,610
1919-20	124	153	168	187	205	218	473	1912	3072	1908	464	289	458,700	555,303
Average	.....	.....	.....	.....	.....	.....	.....	1907	3222	1655	483	349	.....	.....

Location of Station:—In N.W. $\frac{1}{4}$ Sec. 28, T. 6, R. 25, W. 4th, $\frac{3}{4}$ of mile below on Macleod trail and 2 miles above confluence with Belly River.
Maximum and Minimum Stages:—The maximum stage recorded is 10502 c.f.s., on June 22nd, 1916, and minimum stage 62 c.f.s., Jan. 24th, 1919
Flood:—No estimate.
(a) Acre feet during the irrigation season is computed at the rate of 60 a.f. per sec. ft. per month.

TABLE No. 7
 MEAN MONTHLY DISCHARGE OF CROOKED CREEK NEAR WATERTON PARK—DRAINAGE AREA 26 SQUARE MILES
 (RECORDS GIVEN TO NEAREST UNIT)

SEASONS	NON-IRRIGATING SEASON						IRRIGATION SEASON					Acre Feet Irrigation Season	Total Acre Feet	
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.			Sept.
1910	19.							82z	10.	1.	1.	14.	1,560z	
1910-11	21	30z					31	30	36.	15.	44.	101	17,820z	
1911-12		10						43p	14	22	5		9,180z	
1912-13								35	36	14	10	4	6,420z	
1913-14	10						22z	46	26	9	5	6	6,480z	
1914-15	30					30z	18	54	90	61	44	38z	6,780	
1915-16	45z					28z	44	104	91	53	10	10	21,420z	
1916-17	9							29	94	14	3	3	20,100	
1917-18	3							15	17	4	3	5	13,080	
1918-19	4								10	2			13,620	
1919-20	1												3,660	
1920-21													2,580	

(a) Acre feet during the irrigation season computed at 60 a.f. per sec. ft. per month.

During 1912 a number of measurements were made on the tributary streams, by which an idea is given of the extent to which the discharge of the river at the proposed dam site is increased above the measured discharge at Waterton Mills.

TABLE No. 8.

MEASUREMENTS ON TRIBUTARY STREAMS TO THE WATERTON RIVER DURING 1912

Entering river above proposed dam.

Stream	May 21	June 14	July 31	Aug. 17	Sept. 6	Oct. 14	Nov. 7
Cottonwood Creek	72.0	b(20.0)	17.9	14.7	10.8	7.0	12.7
Crooked Creek..	115.0	12.7	Aug. 1st 6.6	5.7 Aug. 19	b(5.0) Sept. 9	b(5.0) Oct. 16	6.6 Nov. 9
Pine Creek	113.0	18.7	19.5	11.4	10.6	11.0	11.6
Yarrow Creek	282.0	108.0	63.0	27.0	19.0	33.0	28.0
(a) Drywood River	b(100.0)	80.0	50.0	28.0	15.0	20.0	30.0
(c) TOTALS	682.0	239.4	157.0	86.8	60.4	76.0	88.9
Measured discharge of Waterton River at Waterton Mills	2245.0	2086.0	799.0	390.0	266.0	230.0	290.0
Estimated discharge at proposed dam	2927.0	2325.4	956.0	476.8	326.0	306.0	378.9
Per cent. inc.	30%	11%	19%	22%	22%	33%	30%

Entering river below proposed dam.

Stream	May 22	.....	June 14	Aug. 19	.....	Oct. 18	.....
Foothill Creek ..	28.0	.....	2.0	0.10	.....	2.1	.....

(a) Measured above Yarrow Creek.

(b) Estimated by writer.

(c) Indicates approximate increase in flow of Waterton River at the proposed dam above the measured discharge at Waterton Mills.

The discharge of Foothill Creek, which enters the Waterton River below the proposed dam site is very small in comparison with the discharges of tributary streams above the dam site.

By reference to Tables No. 5 and No. 6 it is observed that records are concurrent for the period November 5th, 1915, to date.

The relative average difference between discharges at Waterton Mills and at Standoff for the irrigation season, May to September inclusive, during the years 1916 to 1920, is as follows:—

TABLE No. 9.

AVERAGE DISCHARGES OF THE WATERTON RIVER IN C.F.S.

Measured at	May	June	July	August	Sept.
Waterton Mills	1433	2628	1399	392	274
Standoff	1907	3222	1655	483	349
Difference	474	594	256	91	75
Percentage increase	33%	22%	19%	24%	27%

ESTIMATE OF DISCHARGE OF WATERTON RIVER AT PROPOSED DAM SITE DURING IRRIGATION SEASON

For the purposes of an estimate of the discharge of the Waterton River at the proposed dam site Table No. 10 is compiled under the following assumptions:—

(a) For the seasons 1908 to 1915, the measured discharge of the River at Waterton Mills is increased by 25% for the month of May and 20% for the months June to September.

(b) For the years 1916 to 1920 the measured discharge at Standoff is decreased by 10% for the month of May and considered to be equal for the months June to September, by assuming the inflow from Foothill Creek and coulees to be offset by seepage and evaporation losses from the river.

TABLE No. 10.

ESTIMATED DISCHARGE OF WATERTON RIVER AT PROPOSED DAM SITE OF THE DISTRICT

Year	May	June	July	August	Sept.
1908.....	.....	4573	2223	584	282
1909.....	1909	5649	2569	939	378
1910.....	2681	2183	996	416	709
1911.....	2062	3727	1363	892	1506
1912.....	1886	2092	1446	544	324
1913.....	1961	4059	1359	765	327
1914.....	2391	2391	1086	517	472
1915.....	1711	2055	1177	595	608
1916.....	1537	4819	2939	781	647
1917.....	2189	3868	1950	449	228
1918.....	1354	2559	730	415	421
1919.....	1780	1794	751	306	164
1920.....	1721	3072	1908	464	289

WATER RIGHTS

The ownership of water is vested in the Crown, but is subject to use by an applicant upon receipt of a license issued by the Minister of the Interior.

The preliminary step required to obtain a Water Right is an Application or Memorial filed with the Commissioner of Irrigation, which shall have preference according to the date of its filing.

Licenses which are issued shall have priority among themselves, in the order of the original valid applications. Licenses carry a right only to a beneficial and economic use of water, subject in quantity to the capacity of the constructed works, and under such regulations provided, or left to the discretion of the Minister, as will insure protection of other and prior rights.

Each application or license, is given two numbers to designate priority. One number shows the priority in the particular stream, from which water is to be taken. The other number indicates priority in the drainage basin as a whole. It shows the relation of a right in a tributary stream, as compared with a right in a larger stream, which is supplied in some proportionate part by the water contributed by the tributary stream.

The application for a water right by the South Macleod Irrigation District is now allocated by an order of the Privy Council P.C. No. 3829, dated October 12, 1921, and provides for 56,793 acres of land with 85,190 acre feet of water. This is equivalent to $1\frac{1}{2}$ acre feet per acre.

No prior water rights exist on the Waterton River itself, but several applications having priority are on the tributary streams which enter the Waterton River above the proposed dam site.

There are a number of applications or licenses for water rights having priority, on the Belly River, below the mouth of the Waterton River and the Old Man River, for which the supply of water is partly contributed by the Waterton River. Not all of these applications are complete and definite quantities have not been fixed. An estimate of quantities of water or applications, authorized and pending, may be summarized as follows:—

TABLE No. 11.

APPLICATIONS OR LICENCES FOR WATER RIGHTS PRIOR TO THE
RIGHT OF SOUTH MACLEOD IRRIGATION DISTRICT

Stream	Purpose	Area	Acre feet	(a) Per cent. from Waterton	Acre feet
Waterton	(Nil)	0	0	-----	-----
Tributaries to Waterton River	Irrigation	1888	2832	100%	2832
Belly River below Waterton River	Irrigation	1431	3734	75%	2800
Old Man River	Irrigation	893	1340	20%	268
	Industrial	-----	21386	20%	4277
Total estimated acre feet to be supplied by Waterton River	-----	-----	-----	-----	10,177

(a) Estimated proportion to be supplied by the Waterton River drainage basin.

With respect to the above quantity of water to be supplied by the Waterton River the quantities in cubic feet per second by months may be taken approximately as follows:—

	May	June	July	August	Sept.
For irrigation	10	30	33	20	7
For industrial purposes	15	15	15	15	15
Total	25	45	48	35	22

QUANTITY OF WATER REQUIRED FOR IRRIGATION

DUTY OF WATER

Every locality may be generally classified as to conditions of rainfall, under three general headings, viz.: humid, semi-arid and arid. The two extremes are susceptible to more or less definite methods of agricultural development, i.e., by dry farming or irrigation.

A semi-arid country with its variation of wet and dry years or cycles of years, may result in the practice of both methods according to the conditions of the year and the character of crops grown. The uncertainties of climate in a semi-arid country make it difficult to apply the factors relating to irrigation. In different years and for different crops the actual need of water may vary materially, both as to the total quantity and the times when its application would be most beneficial.

For large areas a conservative general use must be considered with regard to the average condition of climate, soils and crops. In this respect the Dominion Government upon general investigation have adopted as a legal "duty of water" an amount equal to $1\frac{1}{2}$ acre feet per acre per season.

The amount as an average applied to diversified crops, some of which may need more water and others less, is sufficient in this locality to insure good crop returns.

RELATIVE USE OF WATER DURING IRRIGATION SEASON

The relative proportion of water required by months out of the total for the season will vary with the kind of crops and the amount and time when rainfall may occur.

The use of monthly rainfall records cannot, in a practical manner, be used for any forecast of monthly irrigation requirements. The record for any month may be for a rain which occurred 10 or 15 days after a crop actually needs water, and drought periods of even 10 or 15 days are recognized to materially reduce crop returns.

The farmer who is accustomed to the use of water and who knows the value of its application at the right time, will irrigate as the crops require water and take no chances on the prospect of a rain coming later. If a rain does come immediately following an irrigation, it does no harm and may assist or even preclude the

need of another irrigation which would otherwise follow. But these conditions are problematic and in dealing with the relative amounts by months or total for the season, the effect of rainfall is considered to apply only in an abstract form.

The following percentages by months are used as being an average of irrigation requirements based on known uses of water in the Province, viz.: May, 10%; June, 30%; July, 33%; August, 20%, and September, 7%. The percentages will vary during different years. In wet years the proportion during June and July may be less and in dry years greater.

Under the provision of "The Irrigation Act" the irrigation season is defined as the period May 1st to September 30th. This fixes the period when diversion of water from a stream may be legally made, excepting under license for water right for storage purposes or under other special provisions.

Experience indicates that the use of water during October on land to be planted to grain in the spring has certain advantages.

The water so supplied is retained during the winter and insures sufficient moisture in the spring to germinate seeds and start crops with a vigorous growth. Spring irrigation of grain crops cannot always be undertaken for the reason that time is required to prepare land and seed the crop, which may not be completed until the middle of May. Irrigating a crop up does not meet with good success on all classes of soil due to a hard crust forming on the surface.

In view, however, of the irrigation season being now fixed for the period May 1st to September 30th, no provision is made in this report dealing with the question of water supply from the river for irrigation during October.

It would perhaps be advisable for the district to make application to safeguard a right for diversion of water in October for the reasons mentioned.

SEEPAGE AND EVAPORATION

To the amounts of water required on the land an allowance must be added to compensate for losses in seepage and evaporation in the canals and ditches carrying water to the land.

Losses by seepage will vary with the differences in character of soil through which the canals pass. Due to the gravelly conditions of the soil at various places in the district, through which the irrigation system would pass, although in some places not seen at the surface, extra large losses must be expected at these places.

Evaporation will vary according to relative conditions of temperature, humidity and wind. In the district all three of these conditions are conducive to high evaporation.

Considering both factors and the fact that a large proportion of the irrigable area is in the northern part of the district farthest from the point of diversion, the losses must be taken relatively high, which for the purposes at hand is assumed at 40% of the amount of water diverted from the river.

IRRIGATION FACTOR FOR DISTRICT

The "Irrigation Factor" is the percentage of the gross area of irrigable land which is irrigated in any one season. For large

areas of land subject to diversified farming operation the percentage may be taken at 80%.

QUANTITY OF WATER REQUIRED BY THE DISTRICT—

Gross irrigable area embraced within the District including Crown lands	60,000 acres
Net irrigable area for any one season at 80% irrigation factor	48,000 acres
Quantity of water applied to the land per season at 1½ acre feet per acre	72,000 a.f.
Allowing 40% of the amount diverted as an estimated loss for seepage and evaporation the total diversion equals	120,000 a.f.

AVERAGE RATES OF DIVERSION

	May 10%	June 30%	July 33%	August 20%	Sept. 7%	Total 100%
Acre feet	12,000	36,000	39,600	24,000	8,400	120,000
Flow in sec. feet	200	600	660	400	140	.....

COMPARISON OF WATER RIGHTS WITH STREAM FLOW

The total amount of water required from the Waterton River to supply the district and water rights having priority to the district is estimated as follows:—

	May	June	July	August	Sept.
For the District.....	200	600	660	400	140
For prior rights	25	45	48	35	22
Total	225	645	708	435	162

By comparing the above with Table No. 10 it will be observed that the estimated discharge of the Waterton River at the proposed dam site is sufficient to supply requirements excepting for August 1910, 1918 and 1919, during which months there is a small deficiency.

VALUE OF IRRIGATION

The value of irrigation is based on the additional net returns from land under irrigation as compared with the net returns without irrigation. The returns in either case must be considered with regard to the kinds of crops capable of being produced by the two methods of farming, and the net returns determined by deducting the respective costs for producing the crops.

Due to conditions of soil and climate facilities for preparing land, distance from markets, etc., each locality offers a new problem. In the district the kind of crops which may be grown under dry farming methods is limited to grain. The best methods of dry farming in semi-arid climate require that the land be summer-fallowed each alternate year but notwithstanding this, crops fail in a degree, according to the adverse conditions resulting from the amounts and time when rains may occur and because of soil drifting, hot winds, etc.

Under irrigation the kind of crops which may be grown is limited only by the length of the growing season required to mature crops. Under irrigation not only grain crops but in addition other kinds of crops can be successfully grown each year, such as alfalfa, mixed grass hay, peas, roots, vegetables, corn, sunflower, etc.

No summer fallowing is required for lands under irrigation and by it perennial crops such as alfalfa, timothy, mixed hay, pasture, etc., can be grown at a saving in cost for land preparation and re-seeding.

In addition to the benefits assured for better yields and a variety of crops grown under irrigation certain other advantages are obtained which are of material worth but can not be easily expressed in money value. These are the advantages resulting out of mixed farming, obtained by the additional value of crops when fed to livestock, the saving in cost of marketing, the retaining of fertilizer on the land and finally by the growth of trees, shrubbery, a garden, etc., better and more comfortable living conditions are provided and more valuable homes established.

For purposes of arriving at the probable difference in the returns from the land under dry and irrigated farming the figures used in the following are estimated at amounts intended to provide conservative results, i.e., the averages used for the prospective yields under irrigation are fair averages under good farming conditions and the averages for dry farming relatively high for the district as a whole.

ESTIMATED RETURNS FROM AN IRRIGATED FARM OF 160 ACRES

The following table gives the estimated yields and value of crops on a 160 acre tract under irrigation. The unit prices used are taken as net average feeding values in the district under normal conditions.

TABLE No. 12

ESTIMATED RETURNS FROM AN IRRIGATED FARM OF 160 ACRES

Crop	Area Acres	Estimated Yield per Acre	Unit Price	Total Value	Value per Acre
Alfalfa	80	3.0 tons	\$ 15.00	\$ 3,600.00	\$ 45.00
Oats.....	40	60.0 bus.	.35	840.00	21.00
Barley	25	50.0 bus.	.50	625.00	25.00
Peas.....	5	30.0 bus.	1.50	225.00	45.00
Potatoes.....	5	250.0 bus.	.60	750.00	150.00
Garden Roots	1	.....	.....	100.00	100.00
Building yards, ditches, etc.	4	.....	.....	0.00	.....
	160	.....	.....	\$ 6,140.00	\$ 38.37

ESTIMATED RETURNS FROM A DRY FARM OF 320 ACRES

The following estimate is made on a basis of 160 acres of producing land, requiring 320 acres to the farm. The prices are values estimated to be received by the farmer at the elevators under normal conditions.

TABLE NO. 13

Crop	Area Acres	Estimated Average Yield	Unit Price	Total Value	Value per Acre
Wheat	160	20 bus.	.90	\$ 2,880.00	\$ 18.00
(or			(a)		
Oats	160	35 bus.	.30	1,680.00	10.50
(or			(a)		
Barley	160	25 bus.	.40	1,600.00	10.00

(a) The unit prices for oats and barley are not worth as much per bushel delivered at the elevators as they are when fed to stock on the farm.

ESTIMATED COST OF PRODUCING CROPS

FOR IRRIGATED LAND	160 ACRES	TOTAL COST
(1) PLANTING ANNUAL CROPS on $\frac{1}{2}$ the area, plowing, harrowing, seed, seeding, etc., at \$6.00 per acre		\$ 480.00
(2) PERENNIAL CROPS on $\frac{1}{2}$ the area on a basis of 15% of the initial cost for land preparation, seed, seeding, etc., at say \$12.00 per acre—\$1.80 per acre per year		144.00
(3) IRRIGATION, 2 men 30 days at \$3.50 each	\$ 210.00	
REPAIRS to small ditches and structures	160.00	
LAND PREPARATION AND FARM DITCHES on a basis of 8% of the estimated initial cost of grading, leveling land, ditches, structures, etc., at say \$20.00 per acre or yearly charge of \$1.60 per acre.....	256.00	
OPERATION AND MAINTENANCE at \$1.50 per acre	240.00	
REDEMPTION OF BONDS on an assumed principal charge of \$34.00 per acre to be repaid in 25 years or at an average of \$1.36 per acre per year	217.00	
INTEREST on outstanding indebtedness at $6\frac{1}{2}\%$,—less interest earned on Reserve Fund leaving an average charge of \$1.50 per acre per year	240.00	
		\$1,323.00
(4) HARVESTING AND MARKETING at an average cost for all crops at \$10.00 per acre		1,600.00
(5) INTEREST ON CAPITAL INVESTED IN LAND on the basis 160 acres at \$20.00 per acre at 6%		192.00
(6) TAXES, etc., on 160 acres at say 25c per acre		40.00
Total for 160 acre farm.....		\$3,779.00
Average cost per acre		\$ 23.62

FOR DRY FARMING—(on 320 acres in the farm with 160 producing)—

(1) PLANTING ANNUAL CROPS, discing, harrowing, seed, seeding, etc., 160 acres at \$4.00	\$ 640.00
(2) SUMMER FALLOW, charged from work done in preceding year to producing area, 160 acres at \$4.00	640.00
(3) HARVESTING AND MARKETING on the basis of grain crops only, 160 acres at \$5.00	800.00
(4) INTEREST ON CAPITAL INVESTED IN LAND on the basis of \$20.00 per acre for 320 acres at 6%	384.00
(5) TAXES, etc., on 320 acres at say 25c per acre	80.00
Total for 160 acres producing crops	\$ 2,644.00
Average cost per acre	\$ 16.52

NET RETURNS

IRRIGATED FARMING	Per acre.	Total
Estimated value of gross yield.....	\$ 38.37	\$6,140.00
Estimated cost of production	23.62	3,779.00
Profit	\$ 14.75	\$2,361.00

DRY FARMING on the basis of an average for wheat in the district—

Estimated value of gross yield.....	\$ 18.00	\$2,880.00
Estimated cost of production	16.52	2,644.00
Profit .....(a)	\$ 1.48	\$ 236.00

NET GAIN FOR IRRIGATED LAND

Profit by irrigated farming	\$ 14.75	\$2,361.00
Profit by dry farming	1.48	236.00
Net Gain	\$ 13.27	\$2,125.00

(a) The value of a 20 bushel wheat crop is generally considered to about offset the cost of production.

IRRIGATION SYSTEM

Preliminary surveys, maps, plans, etc., have been made under the direction of the Commissioner of Irrigation for purposes of making a general estimate of cost and to determine the area of land which could be irrigated.

With the aid of the maps, plans, and relating information, and a field inspection a good idea is obtained of the general plans for the irrigation works.

DIVERSION DAM AND HEADGATES

Two sites have been considered for the dam and headgates. They may be termed the Upper Site, situated at about the N.E. cor. Sec. 11, T. 5, R. 27, and the Lower Site, situated in the N.W. $\frac{1}{4}$ Sec. 18, T. 5, R. 27. The Upper Site is at a bend in the river where the canyon is probably not over 300 ft. wide at the bottom. Both banks are high, the right bank being nearly vertical and consisting of sandstone. The left bank has a slope of about 1 to 4. The bed of the river shows sandstone of fairly firm character. The conditions provide good facilities for an inexpensive dam and as the canal can be taken out with its bed at the bottom of the river channel, a low dam will serve all purposes.

The difficulty in connection with the use of this site is in the construction of the Main Canal for a distance of a mile and a quarter below the dam. From the point of diversion, the canal would run for about $\frac{1}{4}$ mile on a bench, averaging 8 to 10 feet above the bed of the river. Below this bench and for the next mile the canal would run at and near the base of a steep bank (not a cut bank), along which the river in times of flood washes with considerable force, and has left numerous gravel and sand bars with intervening high water channels. The river bottom in this section has a width of $\frac{1}{4}$ of a mile or more. For the next mile and a half the canal may be run on an economic cutting and then goes through a narrow neck of

land by tunnel and then along side hill slopes for $\frac{3}{4}$ of a mile, where it crosses Foothill Creek by a flume and then for one-half mile along steep side hill slopes to a point where it comes on to a secondary bench. From this point on, the canal may be easily adjusted to economic cutting.

The conditions over the mile of ground subject to overflow offers two objections, viz.:—the maintenance of a canal bank on ground, subject to overflow by a swift moving stream, and losses from the canal which may occur in the gravelly and sandy material in which the canal would be located for part of its length.

These conditions have prompted investigations for another site for a dam which has been chosen at a point about $1\frac{1}{2}$ miles below the Upper Site.

At this site the water surface in the canal is taken out at elevation 3551, 19 feet below the water surface of the canal taken from the Upper Site. The elevation 3551 is governed by the depth of extra cutting in the canal between the dam and the tunnel, much of which will vary from 10 to 22 feet in depth, the length of the tunnel and the elevation necessary to reach the top of the secondary bench below the tunnel.

A water surface in the canal at elevation 3551, at the point of diversion requires a dam 17 feet high. The length of the dam is planned at 550 feet and has an embankment at one end 380 feet in length, of which 300 feet will vary from 8 to 16 feet in height. Any lowering of the height of this dam would require corresponding extra cutting in the diversion canal for most of the distance to the tunnel (9,000 ft.) an extra length of tunnel and a longer line before reaching economic cutting on top of the secondary bench.

The Lower Site has been used in connection with the plans and for the estimates.

MAIN CANAL

Considering the Main Canal from the Lower Site, the more difficult and expensive construction work is confined to the upper end between Station 0 and 170, a distance of about $3\frac{1}{4}$ miles.

From Station 0 to Station 40 the canal line runs on the flats adjacent to the river. It begins with a cut of 15 feet at the point of diversion and reduces to a normal cut of 5 feet within 1,500 feet.

From Station 40 to Station 90, the canal runs through a bench adjacent to the river with centre cutting from 6 to 22 feet. This extra cutting is required in order to set the canal back from the river banks.

At Station 90 the line reaches a peninsula of high land between the Waterton River and Foothill Creek, the side hill slopes of which on the Waterton River side are very steep. To avoid this, a tunnel of 650 feet in length carries the canal through a narrow neck to the side slope of the canyon of Foothill Creek.

In the next 4,000 feet two deep cuts of about 40 feet in depth are to be made through two points of land, jutting out from the main side of the canyon. Both of these cuts are about 600 feet in length.

Beginning at Station 136 + 30 to Station 145 + 00, a flume 870 feet long is required to cross Foothill Creek. From the lower end of the flume the canal runs along steep side hill slopes a distance of 2,700 feet where it reaches, at Station 172, the top of a secondary bench. From this point on, throughout its entire length, the canal runs in fairly direct alignment and excepting at drops, can be located at an economic cutting on ground, which has a transverse slope of from 5 feet to 15 feet in 100 feet.

STRUCTURES

Between Station 350 and Station 1,606 (the latter station is the beginning of the Monarch Branch) a fall of 390 feet in excess of the necessary canal grade is required to be taken up by drops or chutes. The excess fall has been concentrated in certain lengths of the canal as follows:—

Stations	Length feet	Total Fall	Drops		Capacity of Canal as planned
			No.	Height	
350	0	5	1	5'	396.3
610 to 640	3000	71.2	{ 8 1	{ 8' 5.6' }	577.3
768 to 781 + 80	1380	45.0	{ 5 1	{ 8' 5' }	542.4
1010 + 50 to 1050	3950	71.1	{ 8 1	{ 8' 5' }	501.4
1529 to 1606	7700	197.7	{ 18 14	{ 7' 5' }	220.0

A syphon, flumes and bridges are required on the main canal as follows:

SYPHON

Between Station 299 + 70 and Station 315 + 70 a wood stave pipe 9 feet in diameter is proposed to cross Scotts Coulee.

FLUMES

Five flumes are proposed as follows:—

No.	Station to Station	Length	Capacity
1	136 + 30 to 145 + 00	870	633 c.f.s.
2	1260 + 80 to 1265 + 80	500	384 c.f.s.
3	1396 + 00 to 1402 + 00	600	343 c.f.s.
4	1427 + 50 to 1431 + 50	400	343 c.f.s.
5	1492 + 50 to 1496 + 00	350	308 c.f.s.

BRIDGES

About 30 bridges over the main canal will be required at road allowances and other points.

BRANCH CANALS AND DISTRIBUTIONS

There are twelve main branch canals with distributaries in the district, and a number of small laterals branching directly from the main canal. These provide for the irrigation of land as follows:—

Branches, Canals and Distributaries	Irrigable Area
Waterton	1041.4
Skeeding	2187.6
Standoff	3777.0
M.C.P.	1076.1
M.C.S.	2899.6
Patterson	2731.9
Secondary A.	7102.4
Pugan	2163.3
Wellsville	9242.2
Monarch	9317.7
Orton	5527.0
Macleod	4590.0
Distributaries from Main Canal	9350.5
Total	<u>61006.7</u>

LATERAL WORKS

SIZE OF LATERALS

IRRIGATION PERIOD

It is necessary in planning the size of an irrigation system to provide sufficient capacity to irrigate land in a short period of time.

The reasons are:—

(a) All of the crop of one kind on a farm may need water about the same time. Should only a small flow of water be available, although delivered for a long period of time, part of the crop would dry up while other parts were being irrigated.

(b) A small quantity of water cannot be economically applied to land on account of extra losses in seepage. With a small head of water the upper parts of a field will be saturated before the lower end will receive enough.

(c) Because of extra seepage losses in the continued use of small heads of water, the underground water is supplied faster than it can drain out or be taken up in crop growth. It may rise to an elevation that will damage deep rooted crops and necessitate the reclaiming of the land by drainage systems.

(d) It is a saving of time and expense to the irrigator to use a large "ditch head" at intervals over a short period of time, than to use a small ditch requiring all of the irrigator's time.

It is desirable therefore that the capacity of ditches shall be sufficient to supply the land within a period of time, adjusted to the requirements of growing crops, that will protect crops from damage, and to save loss of water and time required in irrigation. The period may be taken as ten days.

DEPTH OF APPLICATION

The depth which may be practically applied to land will vary largely with respect to the degree of care taken in preparing land for irrigation, to its slope and the character of soil. Where land is well prepared for irrigation, both as may regard the surface of the field and the size and number of field ditches, the depth of water which may be applied in a practical way, may be taken at 4 inches for any one irrigation. The full measure for the whole of the crop growing season may be supplied by repeating four inch irrigations at such irrigation periods as the respective kind of crops may require.

A ditch that will supply a 4 inch irrigation in 10 days, will supply a 6 inch irrigation in 15 days. The latter figures are used in the computations made by the government.

DEMAND FACTOR

The Demand Factor is a term chosen to designate the percentage of the maximum area of land which may require irrigation in any one irrigation period.

It is the product of the Irrigation Factor and a Crop Variety Factor.

The Irrigation Factor is the percentage of irrigable land out of the total irrigable area which would be irrigated in any one season. The balance would be land either not cropped or in crops not requiring irrigation for the season and varies from 100% for an individual field all in crop, to an average of 80% for large areas. This variation depends upon the degree to which the area in question has been brought under development and cultivation.

The Crop Variety Factor is a term chosen to designate the percentage of land in crop and under irrigation for the season, which would require water in any one irrigation period, of say, ten days. Where a variety of crops are grown on a farm it is reasonable to assume that all of them will not require irrigation simultaneously in any one irrigation period.

For example: In a 160 acre farm 80 acres may be planted to grain and the adjoining 80 acres planted to alfalfa. Considered individually, each 80 acre crop requires a supply of water based on 100% of the area, but if the grain is irrigated in one ten-day period and the alfalfa in the following ten-day period, then a supply ditch large enough for both fields may be based on 50% of the total area in crop but in the following year all of the farm may be in alfalfa requiring a ditch for 100% of the area.

It is reasonable to assume as more units are considered in the aggregate with probability of greater variation in crops or water requirements, that as the areas increase the Crop Variety Factor will gradually decrease below 100%. If, out of the total area, half is considered to be in grain and half in alfalfa, and not requiring water in the same ten-day period, then, the factor would be 50%. If a third crop can be brought in for another ten-day period the factor would be 33 1/3%. For large areas of diversified crops, the Crop Variety Factor may be conservatively taken at 60%. This would provide for the overlapping of two crops within a ten-day irrigation period.

The Demand Factor becomes the product of the Irrigation Factor (which may vary from 100% for small areas to 80% for large areas) and the Crop Variety Factor (which may vary from 100% to say 60% respectively). It therefore may vary according to the size of the tract of land from 100% to 48%.

In determining lateral ditch capacities, the Dominion Government has provided for a 6-inch irrigation in 15 days on a demand factor varying from 100% for areas up to 320 acres, and gradually decreasing to 50% for an area of 6,400 acres. A 6-inch irrigation in 15 days at 50% demand factor is equivalent to 6 inches in 30 days on a 100% demand factor.

These provisions provide ample size for the irrigation system.

POSSIBILITY FOR POWER DEVELOPMENT

In considering any general power development in connection with an irrigation system, it is first apparent that while the market for power will vary during different months, it would not vary in the same proportions as would be generated by the relative flow of water used for irrigation. It would naturally follow that any extended power development could only be considered upon making special arrangements for additional quantities of water to be taken from the River and to provide for a return to the River of any excess over the needs for irrigation; or confine the development and sale of power within limits that would be generated by water used in irrigation.

With respect to the latter condition a scheme has been considered to provide power in order to pump water on to land which cannot be covered by a gravity system in what is known as the Pierce District. For this purpose alone, the flow of water in the canals for power purposes could be maintained in direct proportion to irrigation requirements, assuming the irrigation factors in the Pierce District to be the same as those in the South Macleod District.

If the arrangements tentatively considered for the Pierce District were to be extended upon, with the idea of furnishing power for other purposes, the market for the additional power must be of a character that would largely fit in between the relative amounts of power used from time to time by the Pierce District. Such a market of any size is difficult to obtain and would probably result in the amount of power sold to average very low as compared with the capacity of the plant required to furnish the peak load.

The use of a canal nearly 30 miles long to supply water during the winter months for power purposes, cannot be contemplated without expecting trouble. This may occur because of the flowing of slush ice through structures, the freezing of ice in the syphon and chutes or drops, and the difficulty in clearing the canal, during the spring thaw, of the thick ice which will have formed in the canal. There would be no time for necessary maintenance work in the main canal.

Considering these features in a general way it appears that any power development should be limited to the maximum requirements of the Pierce District if that scheme is decided upon, and limit any surplus to such sales as could be made during a period including the irrigation season, but to the exclusion of the winter

season or such additional necessary time as may be required for maintenance work.

If a power plant is installed at any one of the sections in the main canal where falls occur, the provision for it should be entirely separate from the drops or chutes. These would act as a by-pass in the event of any disorders at the power plant or its appurtenant works.

The cost of installations, if the present tentative plans for the Pierce District are carried out, should be entirely borne by that district. Such plans would also require an enlargement in the capacity of the Main Canal, which should be paid for direct out of the bond issue for that district. An agreement would need to be entered into to provide for Maintenance and Operation of the Main Canal and other works which would be of common use to both districts.

In order to show the comparative amounts of power which may be produced at the several sections in the main canal, where drops or chutes occur, the following table shows the approximate power based on the capacity of the Main Canal as planned for the district.

These figures do not include the additional water that would be required for the Pierce District, if a scheme for irrigation in that district were to be carried out.

TABLE NO. 14

Station to Station	Length of pressure pipe (approve)	Total Fall	Maximum flow of Water	Maximum power from Generators
610+00 to 640+00	3000	71.2	577.3	3190 H.P.
768+00 to 781+80	1380	45.0	542.4	1940 H.P.
1010+50 to 1050+00	3950	71.1	501.4	2835 H.P.
1529+00 to 1606+00	7700	197.7	220.0	3460 H.P.

SUGGESTED CHANGES IN CONNECTION WITH PLANS MADE FOR THE DISTRICT

Upon a general review of the plans and estimate of cost they are accepted subject to the following suggested provisions and alterations.

DIVERSION DAM

The material saving in costs for a dam built at the Upper Site as compared with the Lower Site and cheaper canal construction at all points below, excepting the additional mile and a half between the two sites, directs special attention to the provisions which may be made for this section.

If the canal were to be built well into the base of the side hill along which it would run and the material taken from the hill used for the construction of the entire part of the lower canal bank, then seepage losses from the canal should be small.

In order to provide against the canal bank being washed by high water, the outside may be covered with a substantial thickness

of heavy gravel of which there is an abundance immediately at hand, and at intervals, choosing favorable places, build a series of jetties, the top of which should be above maximum high water and protect the ends with constructed concrete blocks used as riprap or with blocks of sandstone. Large pieces of sandstone of apparently firm character can be obtained at the dam and other points within short hauling distance.

With these provisions there is reasonable assurance of the constructed work being substantial and subject to a reasonable maintenance cost. While general information is available, the details and data are insufficient, particularly with reference to the use of the Upper Site, for an analysis of cost with any degree of accuracy.

The problem presented is a comparison of cost using:—

The Upper Site with conditions for a relatively cheap dam, an additional $1\frac{1}{2}$ mile of canal requiring some expensive appurtenant work and possible extra cost of maintenance, a reasonably economical canal location below to the tunnel, a tunnel, and a chute or drop to join to the lower canal location as against, the Lower Site having an expensive dam, an expensive length of canal to the tunnel and longer tunnel.

Considering this comparison in a casual way with the information at hand it appears that a saving could be made by using the Upper Site of possibly \$75,000.00 and warrants further careful investigation by survey and tests before definitely accepting the construction of a dam at the Lower Site.

For the purpose, however, of arriving at the charge against the land for irrigation works, the estimates prepared by the Dominion Government for the Lower Site are used.

CANAL EXCAVATION

The estimate of quantity of excavation for the Main Canal and branches has been determined by reference to a centre line profile. The capacity of the Main Canal at the head, for which estimates are made, is 633 c.f.s., which is slightly lower than the figure 660 c.f.s. as shown on page 21—"Quantity of water required by the district," due to using a larger seepage factor.

For the smaller lateral works estimates have been compiled for projected lines on topographic maps and the quantities taken for ditches run at a uniform rate of cutting. In order to avoid unnecessary crooked ditches, which make irregular boundary lines to the areas which are to be farmed, it is necessary at times to take extra cutting. For the above reasons and to provide for small knolls, etc., not discernible from the profiles or taken into consideration for the projected ditches, it appears advisable to increase the volume of material for the Main Canal by 10% and for the lateral branches and distributaries by 15%.

The prices used in the estimate for excavation at \$0.30 per cubic yard is higher at the present time than the average cost of excavation of canal and ditches now being built in the neighborhood. A considerable amount of gravel is found at places in the district but does not appear to be cemented or of a character that would be difficult to excavate.

Near the upper end of the Main Canal, between the point of diversion and the tunnel, sandstone is to be seen in places at a depth of a few feet below the surface. In connection with the use of the Lower Dam Site where the canal leading from it is in the deeper cuttings as high as 22 feet, there is some probability of finding sandstone in the bottom portions of the canal section. The use of a ditch from the Upper Dam Site might avoid much of the risk of encountering sandstone and its extra cost for removal.

A test along the line of the canal to ascertain the conditions is a matter of considerable work which was not undertaken in connection with this report.

For the purposes of the estimates a reclassification has been made for all excavation on the following basis:—

For the material in the Main Canal from the headgates to Station 136+30 (beginning of flume across Foothill Creek) the price of excavation is taken at 40c per cubic yard.

For material in the Main Canal below this point 25c per cubic yard.

For material in branches and distributaries 20c per cubic yard.

	Amount of Excav. as per Estimate Cubic Yards	In- creased by per cent.	Amount of Excavation after Increase	Unit Price	Total Estimated Cost
MAIN CANAL					
Sta. 0 to 136 x 30	339,280	10%	373,208	40c	\$149,283.00
Sta. 136+30 to 1606	1,007,596	10%	1,108,355	25c	277,088.00
Branches and Distributaries	861,852	15%	1,292,778	20c	258,555.00
Total					\$684,926.00

These changes increase the cost for Main Canal\$ 22,308.00

Branches and Distributaries Nil

MAIN CANAL STRUCTURES

Tentative designs and estimates have been prepared by the Dominion Government for all main structures. These have been examined and are subject to the following comments:—

TUNNEL—Station 90 to 96+50.

The tunnel required in connection with the Lower Site is 650' long, is designed horse-shoe shaped with maximum radius of 10.4 feet and providing for a normal maximum capacity of 654 c.f.s. The estimated cost for the tunnel is probably low, due to the inadvertent omission of certain constructional features. In addition, it appears advisable for a structure of this character which cannot be enlarged, that extra capacity should be provided to take care of any contingencies which may arise in the future development of the district and use of water at certain critical times.

In every irrigation scheme there are demands made occasionally when the canal system is taxed to its utmost, which may be covered by the overload capacity of the canal system or may result in pro-

visions to be undertaken for enlargements; but tunnels cannot be enlarged, nor can certain other types of concrete structures be conveniently enlarged. The canal itself and all timber constructions are more readily susceptible to enlargement if such is found necessary.

For this reason it appears advisable to consider a larger tunnel and upon including items of cost omitted in the estimates, the cost should be increased to say \$75.00 per foot instead of \$48.80 as used in the estimates, or a net increase of \$17,030.00.

DROPS

Concrete drops come in the class of structures that cannot be conveniently enlarged and where used should be of ample size to provide for the contingencies of an extra demand of water.

Excepting one 5 foot drop, the extra fall of 390 feet in the Main Canal is concentrated in four comparatively short sections. In each of these cases the fall is very rapid, profiles of which resemble flights of stairs.

It appears upon casual examination of the provisions made for drops and including the cost of excavation in the length of canal where the drops would occur, that the substitution of a concrete lined canal section would be cheaper, especially for such part of the length of canal where the slope is steepest.

For the purpose of estimating the cost against the land, the figures for this work as determined by the Government are not reduced.

SYPHON

The length of pipe should be increased to provide for a good contact with the canal section, as a preventive measure to avoid wet and slipping ground under the syphon which may be caused by the seepage of water from the canal, back toward the side slopes of the coulee. The canal at the ends of the syphon is in gravel through which seepage would be large.

The distance by stations between the two ends of the pipe is 1600 feet which is used in the estimates, but the required length of pipe will be longer because of having to be laid on the side slopes of the coulee.

To provide for extra length of pipe as indicated in the foregoing, and for a blow-off valve and trash rack at the intake end, an additional cost of \$5,000.00 is added to the estimate.

FLUMES

Upon examination of the provisions made for flumes and with respect particularly to the length provided for a safe joining of the flumes with the canal, an additional length of about 48 feet or 3 16 foot bents, should be made for each flume. This is to provide better contact with the canal for the same reason as given for the syphon, i.e., as a means of preventing seepage from the canal from making wet and slipping ground on the side slopes of the coulee on which the end foundations of the flume would rest.

The timber used in the flume box should be figured at a fibre stress somewhat lower than the amount used in general practice for

other character of timber construction where the wood remains dry. In this respect the amount of material in the flume boxes should be increased by about 20%.

The flumes are planned to rest on pile foundations. Examples have been had in Alberta where piles were completely rotted at the ground surface and for a foot or more below in a short period of time. Provisions should be made to substitute concrete pedestals under each post supporting the flume, and where situated on the side slopes of the coulees a short pile should be placed under each pedestal to avoid settlement or shifting of the pedestal on ground which may become soft.

The estimated increased cost for five flumes to provide for the changes suggested is \$12,955.00.

WASTEWAYS

No provision has been made for wasteways from the Main Canal which are of urgent use in case of breaks. A partial provision for this can be made at the flumes choosing places where arrangements are most feasible for a discharge of the water through the coulees over which the flumes cross. A further provision for a wasteway may be made at some point, for example: In the neighborhood of the Waterton River Lateral, which might be incorporated as a part of the distributing works.

As a tentative figure applying to provisions for this purpose an addition of \$15,000.00 is made to the estimate.

STOPGATES

No provision appears in the estimates for stopgates in the Main Canal. As the ground drops rapidly away from the Main Canal these are probably not essential to a delivery of water to main laterals or ditches supplied by the Main Canal, when it would be running fairly full. To aid in the division of water when the discharge in the Main Canal is low or variable and for the purpose of closing off water in case of breaks and during process of repairs, it is advisable that provision should be made for stopgates.

An addition is made for five stopgates at the head of the Skelding, Standoff, Wellsville, M.C.S., and Patterson Laterals at a total cost of \$12,500.00.

LATERAL SYSTEM

The provisions made for miscellaneous wooden structures for the laterals, ditches, etc., appear to be adequate.

Provisions for right-of-way, fencing, telephone, etc., appear to be sufficient to meet the respective needs.

ESTIMATE OF COST OF PROPOSED SOUTH MACLEOD IRRIGATION PROJECT

Compiled under the direction of the Commissioner of Irrigation.

HEADWORKS

Excavation (Dry)	4,320 cub. yds. at \$ 0.45	\$ 1,944.00	
Excavation (Wet)	8,320 cub. yds. at 1.50	12,480.00	
Concrete (Plain)	6,919 cub. yds. at 17.50	121,082.00	
Concrete (Reinforced)	480 cub. yds. at 35.00	16,800.00	
Gates, etc.		8,911.00	
Riprap	1,360 sq. yds. at 2.00	2,720.00	
Coffer dam.....		16,394.00	
			\$ 180,331.00

EXCAVATION

Main Canal	1,346,876 cub. yds. at \$ 0.30	404,063.00	
Branches & Distributaries	861,852 cub. yds. at .30	258,556.00	
			662,619.00

DROPS ON MAIN CANAL

Reinforced Concrete.....	5,242.25 cub. yds. at \$ 40.00	209,690.00	
Excavation, riprap, etc.		6,781.00	
			216,471.00

TUNNEL HORSESHOE SHAPE (650 ft. long)

650 Lin. Ft.	at \$48.80 per foot	31,720.00	
Inlet and Outlet		4,340.00	
			36,060.00
SYPHON, SCOTT'S COULEE—1600 ft. long.....			49,699.00

FLUMES, MAIN CANAL

Timber	440,637 F.B.M. at \$ 75.00	33,048.00	
Piling.....	7,476 Lin. ft. at .20	1,495.00	
Piling driven.....	6,160 Lin. ft. at .70	4,312.00	
Inlets and Outlets, etc.		4,232.00	
			43,087.00

GENERAL TIMBER CONSTRUCTION MAIN CANAL AND BRANCHES

Lumber	1,426,215 F.B.M. at \$ 75.00	106,966.00	
Excavation, riprap, etc.		63,755.00	
			170,721.00

GENERAL CONCRETE STRUCTURES

Reinforced concrete	737.12 cub. yds. at \$ 45.00	33,170.00	
Plain	49.6 cub. yds. at 20.00	992.00	
Riprap, Corrugated pipe, etc.		23,969.00	
			58,131.00

RIGHT OF WAY	823.83 acres at \$35.00	28,834.00	
	398.27 acres at 30.00	11,948.00	
			40,782.00

FENCING.....	12.9 miles at 400.00		5,160.00
TELEPHONE LINE	25 miles at 300.00		7,500.00

Total		\$1,470,561.00	
Engineering and Contingencies at 15%		220,584.00	

GRAND TOTAL		\$1,691,145.00	
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TOTAL IRRIGABLE AREA	61,006.7 acres		
COST PER ACRE		\$27.72	

NEW ESTIMATE OF COST
AS REVISED FOR CHANGES SUGGESTED

Estimated cost as compiled under direction of the Commissioner of Irrigation.

Construction	\$1,470,561.00	
Engineering and Contingencies 15%	220,584.00	
		\$1,691,145.00
Add for:		
Excavation, main canal	22,308.00	
Tunnel, enlargement and changes	17,030.00	
Syphon	5,000.00	
Flumes	12,955.00	
Waste ways.....	15,000.00	
Stop gates	12,500.00	
	\$ 84,793.00	
Engineering and Contingencies 15%	12,719.00	
		97,512.00
		<u>\$1,788,657.00</u>

On the basis of 60,000 acres the construction cost per acre is—\$29.81.

NOTE:—These estimates do not take into account a possible saving which may be made if the Upper Site is used for the Diversion Dam, or any saving which may be made by substituting chutes in place of drops.

OPERATION AND MAINTENANCE

OPERATION

An organization must be provided which will regulate the division of water throughout the Main Canal and its various branches and distributaries, so that each farmer may be assured of receiving water in such quantities and at such intervals of time as will protect the crops and provide for their vigorous growth.

The delivery of water under haphazard arrangements cannot be considered. It would only result in unequal divisions of the quantities of water and uncertainties as to when any would be available for use. Turning on or shutting off water even as may be required for one farm requires that provision must be made for the resulting change in flow throughout the system from the particular farm to the headgates or a shifting of the flow to other parts of the general system. The indiscriminate opening and closing of gates without making arrangements elsewhere for the resulting changes in flow, would endanger the system by causing breaks in canal banks and damage to crops and land from the overflow.

To provide water for crops in different parts of the district as required and to insure against damages either to crops and property or to the system itself requires the best care for a systematic control of the works as a whole, by an organization the members of which are well trained for the work, and who are in immediate touch with each other and in position to communicate daily with every farmer in the district.

MAINTENANCE

Under the head of Maintenance comes the work and cost necessary for keeping the system in good working order. This includes the upkeep against ordinary wear, the repair of breaks, clearing of weeds on canal banks and renewals of perishable parts of the system, such as bridges, flumes and other wooden structures. For the renewal of perishable structures, the life of which will vary from 8 to 16 years, a Sinking Fund must be provided by an annual assessment.

ESTIMATED COST OF OPERATION AND MAINTENANCE

OPERATION

1 Superintendent and Engineer	\$ 4,800.00	
1 Water Master	1,800.00	
1 Clerk	1,500.00	
1 Stenographer	1,000.00	
12 Ditch Riders and Gate Tenders at \$1,200.00.....	14,400.00	
Miscellaneous Office Expense, Legal Fees, etc.	6,000.00	
		\$29,500.00

MAINTENANCE

1 Maintenance Foreman	1,800.00	
1 General Mechanic.....	1,500.00	
General Repairs Main Canal, 30 miles at \$200.00.....	6,000.00	
General Repairs for Lateral System based on 60,000 acres at 50c	30,000.00	
		\$39,300.00

SINKING FUND FOR RENEWAL OF PERISHABLE STRUCTURES

Items	Estimated Value of Perishable Parts		
Syphon	\$ 30,000.00 at 6%	\$ 1,800.00	
Flumes	40,000.00 at 10%	4,000.00	
Bridges and miscellaneous timber structures on Main Canal and Lateral System	100,000.00 at 12%	12,000.00	
		<u> </u>	\$17,800.00
Total			<u>\$86,600.00</u>
Average cost per acre for 60,000 acres			<u>\$ 1.445</u>

FINANCIAL REQUIREMENTS

Assume total cost for construction at \$1,788,657.00 and that bonds will sell at a discount netting 95% of their face value. The bonds required for principal would then equal \$1,882,797.00. For convenience assume the amount at \$1,883,000.00.

To meet practical construction progress assume the expenditure on irrigation works as follows:—

1922	30%	\$ 564,900.00
1923	60%	1,129,800.00
1924	10%	188,300.00
		<u>\$1,883,000.00</u>

The following further assumptions are made:—

(a) Bonds issued will mature in 30 years, to be paid in full at the expiration of that term.

(b) A Reserve Fund will be established by setting aside one twenty-fifth of the bond indebtedness during each of the last 25 years of the term.

(c) Interest on outstanding bond at the rate of $6\frac{1}{2}\%$ which shall be capitalized for the first two years.

(d) Interest accruing on Reserve Fund to net $5\frac{1}{2}\%$ to apply as a credit to Interest on Bonds.

On the above basis the cost per acre for Principal and Interest is determined as shown in the following table:

TABLE No. 15
SHOWING NET YEARLY CHARGES TO BE MET BY THE DISTRICT FOR PRINCIPAL AND INTEREST ON BONDS.

Year	Bonds Required for Principal	Capitalized for 2 years at 6½% (a)	Total Out- standing Bonds	Yearly Tax for Reserve Fund	Amount in Reserve Fund	Interest		Net Amount to be met by Assessment	Cost per acre per year on 60,000 acres		Yearly Cost Principal and Int.
						On Bonds at 6½%	Reserve Fund at 5½% Net		Principal	Interest	
1922	\$ 546,900	\$ 604,171	\$ 604,171	\$	\$	(a)	\$	\$	\$	\$	\$
1923	1,129,300	1,249,808	1,853,979			\$132,748		132,748		2.21	2.21
1924	188,300		2,042,279			132,748		132,748		2.21	2.21
1925			"			132,748		132,748		2.21	2.21
1926											
1927			"	81,691	81,691	132,748	4,493	128,255	1.36	2.14	3.50
1928			"	81,691	163,382	132,748	8,986	123,762	1.36	2.06	3.42
1929			"	81,691	245,073	132,748	13,479	119,269	1.36	1.98	3.34
1930			"	81,691	326,764	132,748	17,972	114,776	1.36	1.91	3.27
1931			"	81,691	408,455	132,748	22,465	110,283	1.36	1.84	3.20
1932			"	81,691	490,146	132,748	26,958	105,790	1.36	1.76	3.12
1933			"	81,691	571,837	132,748	31,451	101,297	1.36	1.69	3.05
1934			"	81,691	653,528	132,748	35,944	96,804	1.36	1.61	2.97
1935			"	81,691	735,219	132,748	40,437	92,311	1.36	1.54	2.90
1936			"	81,691	816,910	132,748	44,930	87,818	1.36	1.46	2.82
1937			"	81,691	898,601	132,748	49,423	83,325	1.36	1.39	2.75
1938			"	81,691	980,292	132,748	53,916	78,832	1.36	1.31	2.67
1939			"	81,691	1,061,983	132,748	58,409	74,339	1.36	1.24	2.60
1940			"	81,691	1,143,674	132,748	62,902	69,846	1.36	1.16	2.52
1941			"	81,691	1,225,365	132,748	67,395	65,353	1.36	1.09	2.45
1942			"	81,691	1,307,056	132,748	71,888	60,860	1.36	1.01	2.37
1943			"	81,691	1,388,747	132,748	76,381	56,367	1.36	.94	2.30
1944			"	81,691	1,470,438	132,748	80,874	51,874	1.36	.86	2.22
1945			"	81,691	1,552,129	132,748	85,367	47,381	1.36	.79	2.15
1946			"	81,691	1,633,820	132,748	89,860	42,888	1.36	.71	2.07

TABLE No. 15.—*Continued*
SHOWING NET YEARLY CHARGES TO BE MET BY THE DISTRICT FOR PRINCIPAL AND INTEREST ON BONDS.

Year	Bonds Required for Principal	Capitalized for 2 years at 6½% (a)	Total Out- standing Bonds	Yearly Tax for Reserve Fund	Amount in Reserve Fund	Interest		Net Amount to be met by Assessment	Cost per acre per year on 60,000 acres		Yearly Cost Principal and Int.
						On Bonds at 6½%	Reserve Fund at 5½% Net		Principal	Interest	
1947	-----	-----	"	81,691	1,715,511	132,748	94,353	38,395	1.36	.64	2.00
1948	-----	-----	"	81,692	1,797,203	132,748	98,846	33,902	1.36	.56	1.92
1949	-----	-----	"	81,692	1,878,895	132,748	103,339	29,409	1.36	.49	1.85
1950	-----	-----	"	81,692	1,960,587	132,748	107,832	24,916	1.36	.41	1.75
1951	-----	-----	-----	81,692	2,042,279	132,748	112,325	20,423	1.36	.34	1.70
TOTALS ..	-----	-----	-----	\$ 2,042,279	-----	\$3,716,944	\$1,460,225	\$2,256,719	-----	-----	-----

NOTE:—(a) Interest to be capitalized for first two years. In capitalizing at 6½%, interest is figured as if the Bonds were sold at the beginning of the year in which the cash proceeds are required. If the sale of Bonds can be made at intervals to more nearly meet the time when cash is actually required, the capitalized amount will be less.

In making a review of the foregoing table the principal features to be observed as applied to an estimated gross irrigable area in the district of 60,000 acres are as follows:—

Total Bond Issue	\$2,042,279.00
Average Cost per acre for 60,000 acres	34.038
Average Cost per acre per year to provide Reserve Fund to redeem Bonds	1.361
Interest (after allowing for interest on Reserve Fund) varies from \$2.21 to \$0.34 or an average per year for the period during which interest is payable of	1.504

ABILITY OF THE FARMER TO MEET IRRIGATION CHARGES

One of the principal reasons for failures on irrigation projects is that the areas attempted to be farmed by individuals are too large. The farmer rarely has sufficient money to undertake the necessary irrigation improvements on the whole of a large area of land at the outset, and get it into productive shape. He may try this, however, by the usual procedure of scattered efforts over the whole area or a large part of it. Haphazard methods in irrigated farming will not pay. Where irrigation is required, the success of the farm depends upon the farmer's ability to irrigate his land properly by such quantities of water and at such times as growing crops may require. This requires good land preparation and farm distributing, ditches of such size and so located that irrigation may be applied to the land quickly and uniformly.

A "hit and miss" irrigation produces most unequal results. A farmer accustomed to dry farming on rolling ground may imagine results if it were possible that there should be practically no rainfall on the high knolls and 18 inches or more should fall on the low depressions, and with some unequal distribution between the two. The outcome would naturally be a crop of most spotted appearance, ranging from almost nothing on the high knolls to a rank growth in the low depressions and varying conditions between. It would not mature alike, causing difficulties in harvesting, and on the whole, result in the final returns averaging low and insufficient to pay for the work undertaken in seeding the land and harvesting, to say nothing of partially wasted efforts in poor irrigation.

To avoid these conditions land must be properly prepared, but it takes time to prepare land, and to start perennial crops such as alfalfa, as well as costing a considerable sum of money. Unless a farmer is well financed he cannot expect to complete a very large acreage each year, and especially in the first few years required in building up a farm under conditions that at first may be new to him.

In the meantime assessments are coming due to apply to principal and interest on the bond issue, and a tax for the operation and maintenance of the system which apply to the total irrigable area in each farm regardless as to whether or not the farmer has been able to properly use the water for which the charges are made. These charges must be paid, as under "The Irrigation Districts Act" they are deemed to be in arrears after December 31st of the year in which they are levied, and if not paid prior to July 1st following, the pay-

ment may be enforced under the provisions of "The Tax Recovery Act."

Under these conditions it is apparent that the owner of a large area of irrigable land will find himself so burdened with payments for principal and interest and for operation and maintenance, that there will be insufficient money left for living expenses and to properly carry on operation on that part of the farm which he has been able to bring under productive cultivation. With resources curtailed the farmer cannot take care of whatever work was commenced and the entire holdings deteriorate.

The history of these conditions has demonstrated the necessity of the land on irrigation projects being divided up into small units, and will then result, where properly farmed and irrigated, in successful and prosperous farms.

SIZE OF PRESENT FARM UNITS

Upon making a casual review of the assessment roll as compiled to Nov. 30th, 1921, and excluding the areas owned by the Crown, the areas of land held by individuals are summarized as follows:—

FARMS IN EXCESS OF 320 ACRES OF IRRIGABLE LAND TO THE INDIVIDUAL

Relative Size of Irrigable Land to the Farm	Number of Owners	Total Irrigable Area	Average Irrigable Area
Over 1000 acres	4	5,388	1,347
From 800 to 1000 acres	4	3,754	938
From 600 to 800 acres	4	2,852	713
From 400 to 600 acres	18	8,932	496
From 320 to 400 acres	14	5,063	361
	44	25,989	591

FOR FARM HAVING LESS THAN 320 ACRES TO THE INDIVIDUAL

From 160 to 320 acres	54	12,473	231
Less than 160 acres	160	18,331	114
		56,793	

SIZE OF FARM UNITS APPLICABLE TO THE DISTRICT

Due to the difference in the character of the surface and the kind of crops that may be grown in various localities, there is a difference in the size of the farm unit which a farmer could undertake to successfully handle. In a country that is rough and covered with brush it is obvious that land preparation and time required to put the land in good productive shape will cost more and take longer than on smooth prairie land. It costs more to establish certain kinds of crops than it does for others.

These conditions are the factors which directly affect the farmer's ability to get his farm in shape for profitable production. If it can be done cheaply and quickly it is reasonable to assume that a larger area could be handled successfully than where the work is expensive and requires much time.

A good part of the land in the southern part of the district is very smooth and would require very little grading but on account of the steep slope would require a number of structures on the farm laterals. In the northern part of the district more grading may be required but with less structures in the ditches.

Some of the land could be well prepared for irrigation at a cost that would not exceed \$5.00 per acre while other tracts may cost \$20.00 or more per acre. On the whole the surface can be considered fairly good for economical land preparation. To this may be added a cost for perennial crops at say \$12.00 per acre.

With this comparatively small cost and in view of a part of practically all land holdings having been plowed and cropped at some time in the past, and otherwise improved with houses, fencing, stock and equipment, all of which would require time and capital to start now, it appears that a suitable farm unit would be an area containing 120 to 160 acres of irrigable land.

Where the surface conditions are very favorable and the present owner is unusually well provided with stock, equipment and finances, the area may be increased up to 320 acres of irrigable land.

This area should be the maximum that any individual should attempt to farm under irrigation.

Should outside purchasers come into the district who would have to build houses, fence and equip a farm with stock and implements, the area should not exceed 160 acres of irrigable land and preferably less. The exception in this case would be where a purchaser is able to finance in a measure much larger than the average farmer.

A farm of less than 80 acres in this district is too small to afford a good living and pay all irrigation charges unless the farmer is close to market and grows large quantities of garden products.

Upon considering the present size of the individual holdings on a large part of the irrigable land in the district, there is no doubt that the success of the individuals and the district as a whole will depend upon these large holdings being subdivided and disposed of to new land owners. The irrigation charges for capital, interest and for operation and maintenance, will consume all the profit that the farmer can obtain from the smaller area which he is able to properly prepare and farm, and leave him without resources to carry on new development work or even to care for the areas already commenced and to support himself and family.

POSITION OF PROVINCIAL GOVERNMENT AS GUARANTOR OF BONDS

The Provincial Government has adopted a policy of guaranteeing irrigation bonds for irrigation works on a scheme which may be of merit. The primary object, however, in giving this aid, which incidentally facilitates the sale of the bonds, is to promote resources by improving agricultural possibilities in those localities where unfortunate adverse climatic conditions have resulted disastrously to citizens who had in good faith undertaken to establish homes and earn a livelihood by farming.

In guaranteeing bonds on schemes of merit the Government presumes that not only will irrigation put those in position to profit by increased agricultural returns but also that the landowner will

be able to pay the irrigation rates that shall be assessed on all of the land improved by irrigation works and against which the rates are charged.

Each condition must be fulfilled or else the scheme fails in its objective. The Government protects itself against failure to pay the rates assessed by a special lien having priority over all other claims excepting those of the Crown and certain other special exceptions, and may take recourse through "The Tax Recovery Act" in a sale of the property assessed.

It appears obvious in the cases of large land holdings that there are unfortunate prospects where the owner will find himself unable to meet the assessments on those areas of land in excess of the size he is able to profitably farm, and soon find himself confronted with proceedings for the enforcement of the lien which the Government is obliged by statute to put into effect. The result is that the present farmer may find himself deprived of his property and the Government in possession of land for which it must find new purchasers.

In the event of such circumstances arising, it would appear prudent on the part of both the present land owner and the Provincial Government to anticipate this contingency and to provide for the elimination of the one difficulty in respect of irrigation development in this district, which appears to be a source of trouble to both land owner and the Government, viz.: too much land in individual ownership.

In order to do this and enable the large land owner to protect himself as to immediate obligations and the Government from the probability of having to take over the land owner's obligation, it appears advisable that the land owner and the Government should mutually agree on an arrangement somewhat as follows:

The land owner will convince the Government of his ability to successfully farm a selected area of land and give an option to the Government on all remaining irrigable land, described by legal subdivisions, in excess of the area selected, at a reasonable price per acre which shall be exclusive of all charges for irrigation improvement and cost of colonization. Whereupon the Government will absorb all charges for irrigation rates which may be assessed against the excess area given by the option and shall be entitled to proceed to colonize the land by sales to new purchasers. Provision may be made that whatever profit results from Government sales, after deducting all charges against the land up to the date of the sale, may at the discretion of the Government be paid in cash to the owner from whom the option was taken or may be held in trust to apply to future irrigation rates which may be assessed upon the lands retained by the owner from whom the option was taken.

The alternative to this procedure seems to resolve itself into an attempt on the part of the present large land owner to farm all of his irrigable area or sell the excess land himself. If the results in either case prove insufficient to provide a means for successfully meeting the irrigation charges, then the Government is obliged to take over all of land anyway, inclusive both of the area that might have been optioned and retained, and thereupon proceed to find new purchasers.

CONCLUSIONS

(1) The rainfall is generally insufficient for successful dry farming in the district and all of the district can be materially benefited by irrigation.

(2) The soil, physical features of the land and climatic conditions are suitable for good agricultural development under irrigation.

(3) There is sufficient water in the natural flow of the Waterton River to supply irrigation requirements for the district. For purposes of fall irrigation a right for the diversion of water in October should be obtained.

(4) The provisions made for irrigation works as amplified by the suggestions made for extensions and improvements appear to be adequate for the district, and should be covered by the estimated cost of \$29.81 per acre for irrigation works and a maximum charge of \$34.04 per acre including capitalized interest. This is subject to the possibility of making a reduction in the estimated cost of irrigation works if, upon detailed examination, a change can be made in the location of the diversion works and by substituting chutes for drops.

(5) The increased agricultural returns on any part of the district when the land is properly improved and irrigated will justify the cost of irrigation works and incidental charges.

(6) The land in the district is held in too large individual holdings to be successfully farmed under irrigation by many of the present large land owners. Unless some early provision is made by the large land owner to relieve himself of the irrigation rates to be assessed against that area of land which is in excess of the area that he can successfully farm according to his means, the large land owner will not be able to pay the assessments due for irrigation rates as applied to all of his holdings and the Government will be obliged to foreclose and proceed to colonize the land forfeited.

Respectfully submitted,

D. W. HAYS.

December 27th, 1921.

